HEALTH HAZARD EVALUATION AND TECHNICAL ASSISTANCE REPORT

HETA 91-0142

Dee Zee Manufacturing
Des Moines, Iowa

June 1994

Preface

The Hazard Evaluation and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 660(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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NIOSH Investigators:
JOSEPH E. BURKHART, MS, CIH
ELIZABETH B. KNUTTI, RN

SUMMARY

In March 1991, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation (HHE) at Dee Zee Manufacturing, Des Moines, Iowa. Employees were concerned that they were being exposed to hazardous materials in and around an area called the "buffing shack." Numerous health complaints were listed, with the main complaint being upper respiratory problems.

On October 16, 1991, NIOSH investigators conducted a walkthrough survey at Dee Zee. Information was collected regarding dust exposures in the buffing shack and employees were interviewed as to their current health status. Additional information was also obtained on the health and safety policies at Dee Zee, and the pulmonary function testing which was conducted in 1990 and 1991. Based on the information collected and observations made during the walk-through visit, NIOSH investigators determined that a follow-up environmental and medical evaluation of current buffing room and welding employees was warranted.

On March 5-11, 1992, NIOSH investigators conducted a medical and environmental survey. The medical evaluation was made available to all Dee Zee past and present buffers and welders. The current workers were asked to complete a respiratory questionnaire, performed pulmonary function tests, and completed peak flow measurements over a six day period. The former workers were asked to complete the respiratory questionnaire and performed one pulmonary function test. The environmental portion of the survey consisted of collecting personal breathing zone and work area samples to measure worker exposures to total dusts, welding fume, elemental metals, carbon monoxide, oxides of nitrogen and sulfur dioxide.

Overexposures were found to total dust, welding fumes, aluminum, chromium, carbon monoxide, nitrogen dioxide, and sulfur dioxide for the buffing and welding employees. A health concern for all employees at Dee Zee is the exposure to carbon monoxide. Buffers and welders had similar prevalences of shortness of breath, chest tightness and wheezing, but the buffers had higher prevalences of skin rashes, nosebleeds, ear pain, eye irritation, and sneezing. Foreign objects in the eyes occurred more frequently among the welders.

Eight of the 37 current employees who were medically evaluated had pulmonary function results that fell below the limits of normal. All eight exhibited obstructive respiratory disease patterns; two are buffers and six are welders, and all were either current or former smokers. Four of these individuals also showed a $\geq$20% change in their peak flow data but with no apparent work-relatedness.

Fifteen individuals, eight buffers and seven welders, exhibited a 5% or greater change in FEV_1 across a work day or improvement over the weekend. This suggests response to a worksite exposure.

On the basis of the data obtained, the investigators have concluded that during this investigation a health hazard existed from overexposures to dust, welding fume, aluminum, chromium, carbon monoxide, nitrogen dioxide, and sulfur dioxide. Recommendations for medical surveillance and reducing exposures are included in this report.

Keywords: SIC 3429 (Fabricated Metal Products, Except Machinery and Transportation Equipment, buffing, welding, aluminum, carbon monoxide, nitrogen dioxide, elemental metals, spirometry, peak flow.

INTRODUCTION

In March 1991, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from employees at Dee Zee Manufacturing, Des Moines, Iowa, to conduct a Health Hazard Evaluation (HHE). The request stated, in summary, that employees were being exposed to hazardous materials in and around an area called the "buffing shack". Employees also stated that they were not provided personal protective equipment and that no medical screening or follow-up examinations were conducted. Numerous health complaints were listed, with the main complaint being upper respiratory problems, asthma, and bronchitis. One employee reportedly had a pneumothorax (collapsed lung), and a number of others had sinus or other upper respiratory problems.

On October 16, 1991, NIOSH investigators conducted a walk-through survey at Dee Zee. During that survey, information was collected regarding dust exposures in the buffing shack and employees were interviewed as to their current health status. In addition, information was provided by the company on the health and safety policies at Dee Zee. Dee Zee also provided employee records on the results of pulmonary function testing (PFT) performed in 1990 and 1991. During our walk-through survey, the buffing room was shut down. Dee Zee officials had indicated that the shut down was only temporary due to a change in the product line. Many employees, however, indicated to us that they believed that the shut down was due to the NIOSH site visit. Employees reported to us that after the NIOSH walk-through, operations were immediately resumed.

Company and Occupational Safety and Health Administration (OSHA) sampling records indicate a history of dust exposures in the buffing shack which exceeded the OSHA Permissible Exposure Level (PEL) for nuisance particulate of 15 mg/m^3. Personal, total dust exposures, measured on November 5, 1990 by a private consultant, ranged from 11.2 to 392 mg/m^3 in the buffing shack. Additional samples collected by the Iowa Department of Labor Services (IDLS) showed levels in excess of the nuisance dust standard.

Because of the excessive dust exposures of employees working in the buffing shack, Dee Zee had recently required the use of respiratory protection. Respirator fit testing was accomplished by a respirator distributor.

NIOSH investigators conducted medical interviews with eleven workers who were involved in buffing at some point in their work history at Dee Zee, and who were available on the day of our walk-through visit. In general, employees felt that work conditions have been very dusty, ventilation measures and initial personal protective equipment very crude, medical surveillance substandard, and workers' training/understanding of hazardous work exposures minimal. Upper respiratory symptoms were common among buffers not wearing respiratory protection.

The spirometry records supplied by Dee Zee on 10 workers who are, or were, assigned to the buffing shack were evaluated by NIOSH investigators. Five of the ten buffers had some abnormality in their spirometric measurements. No spirometry testing was available for welders except for welders who had been tested while working in the buffing shack.

During the walk-through survey, the NIOSH investigators observed that the local exhaust ventilation system installed in the welding area was not being used extensively.

Based on the information collected and observations made during our walk-through visit, NIOSH investigators determined that a follow-up environmental and medical evaluation of current buffing room and welding employees at Dee Zee was warranted.

An interim report containing the results of the industrial hygiene survey was issued by NIOSH in November 1992. Seventeen buffers and 21 welders participated in the medical examination. Twelve former workers were also examined but will not be included in this report. All individual participants were mailed their medical results in July and November, 1992.

PROCESS DESCRIPTION

The Dee Zee manufacturing plant opened in 1977. The plant manufactures aftermarket truck accessories such as running boards, brush guards, roll bars, bug shields, and truck bed tool boxes. All materials used by Dee Zee to manufacture products are shipped to the plant. No raw products are processed at the plant. The major materials used at this plant are aluminum sheet and tubular metals of varying composition. Large rolls of aluminum are cut to various lengths and welded to form a product such as a tool box or running boards. TIG and MIG welding processes are used in the welding department. Some electric arc welding is also accomplished on running board steel support structures.

All welding is performed in an open area of the plant. There are local exhaust ventilation hoods at each welding station; however, many of the hoods are not used because of the size of the work piece and the awkwardness of manipulating the exhaust hoods. Also, many exhaust hoods were in a fixed location and not movable to the actual welding site.

Fans are mounted at each work station. We were told that the purpose of the fan was to cool the employee. However, employees informed us that they used the fans to try to blow the welding fumes away from their faces.

Other materials, such as tubular aluminum stock, are received at the plant in various diameters and standard lengths. The tubes are bent using hydraulic presses to form various product shapes, such as brush guards or roll bars. Tubular products are buffed to a high chrome-like gloss using three wheels, 150 and 320 grit and one cotton disc. Additionally, some sanding and grinding is also accomplished. This entire buffing process is enclosed in a room measuring approximately 40x60x40 feet and is accomplished by 12 employees (at maximum conditions) working at nine different work stations.

As a result of the continuing dust problems in the buffing shack, Dee Zee has installed a local exhaust ventilation system in an effort to reduce exposures. However, based on recent sampling results conducted by IDLS and a private consultant, its effectiveness appears to be very poor.

METHODS

On March 5-11, 1992, NIOSH investigators conducted a medical and environmental survey. The environmental portion of the survey consisted of collecting personal breathing zone and work area samples to measure worker exposures to total dust, welding fume, elemental metals, carbon monoxide, oxides of nitrogen and sulfur dioxide. The medical evaluation was made available to all Dee Zee past and present buffers and welders and consisted of a respiratory questionnaire, pulmonary function testing and serial peak flow measurements.

Industrial Hygiene

During the period of March 9-11,1992, environmental samples were collected during typical work shifts in an attempt to evaluate the workers' exposures. Personal breathing zone samples were obtained on all buffers and welders. Area samples for gases were also placed throughout the plant near jobs thought to have potential for excessive exposures. The methods used to collect, sample and analyze substances during this survey are as follows:

Total Dust (Particulates not otherwise classified)

Personal breathing zone samples for the estimation of total dusts (<100 micrometers aerodynamic diameter) were collected on tared 37 millimeter (mm) diameter, 5 micrometer (µm) pore size polyvinyl chloride (PVC) filters, housed in closed-face two piece cassettes. Air was drawn through the filter at a flow rate of 2.0 liters per minute (lpm) using a battery powered sampling pump. Time-integrated samples were collected in the breathing zone of workers for a full shift, generally 7 hours (depending on individual work schedules).

Total dust content was analyzed gravimetrically according to NIOSH Method 0500[1] with the following modifications: The filters were stored in an environmentally controlled room (21 ± 3°C and 40 ± 3% RH) and were subjected to the room conditions for 24-48 hours for stabilization. The total weight of each sample was determined by weighing the sample on an electrobalance and subtracting the previously determined tare weight of the filter.[1] The limit of detection (LOD) for this method was determined to be 0.01 mg per sample. (The LOD is defined as the smallest amount of analyte which can be distinguished from background.)

Elemental Metals

Personal breathing zone samples for the estimation of exposure to elemental metals were collected on 37-mm diameter, 0.8-µm pore size cellulose ester membrane filters, mounted in closed-face cassettes. Air was drawn through the filters at a flow rate of 1.7 lpm using a battery powered sampling pump. Time-integrated samples were collected in the breathing zone of some workers for a full shift, generally 7 hours (depending on individual work schedules). All air samples collected for elemental analysis were digested according to NIOSH Method 7300[1] and analyzed using a scanning inductively coupled plasma emission spectrometer.

The LOD for these compounds were:

ANALYTE	**LOD**
Aluminum	3.0 µg/sample
Chromium	1.0 µg/sample
Lead	1.0 µg/sample
Nickel	1.0 µg/sample

Carbon Monoxide

Personal breathing zone samples for the estimation of carbon monoxide (CO) were collected using Dräger 50/a-D long-term diffusion indicator tubes (Cat.#67 33191). These tubes operate on the basis of the diffusion processes in gases. For example, carbon monoxide molecules to be measured flow into the tube and chemically react with a reagent layer in the tube. This chemical reaction results in a color change of the reagent layer. The mean concentration of carbon monoxide is then calculated from the length of discoloration of the reagent layer, divided by the exposure time. The limit of detection for the detector tubes was 6 ppm.

$$CO_{(ppm)} = \frac{amount\ CO\ indicated\ (microliters)}{volume\ sampled\ (liters)}$$

Area time-weighted average sampling for carbon monoxide was accomplished using Dräger 50/a-L long-duration detector tubes (Cat.#67 28121). Air was drawn through the tube at a flow rate of 20 cc/minute for the duration of the shift. The limit of detection for this method was 6.3 ppm. The length of stain provides a direct reading of exposure to carbon monoxide in microliters, which can be converted to parts per million (ppm) by the formula:In addition, area samples for the measurement of carbon monoxide were also collected using a direct reading Interscan, Series 4000 CO monitor. This monitor was connected to a Metrosonic, Model 714 data logger for signal storage and subsequent analysis. Each monitor was calibrated before, and rechecked after the survey using 25 ppm certified span gas. The limit of detection for this meter is 1% of a full scale reading, which corresponds to 1 ppm for carbon monoxide.

Oxides of Nitrogen

Full shift personal breathing zone exposure estimates for oxides of nitrogen (NO_x + NO_2) were determined using Palmes passive dosimeters (NIOSH Method 6700)[1]. The principle of operation of the dosimeters is that nitrogen dioxide (NO_2) will diffuse through a tube at a rate proportional to its concentration (Fick's Law of Diffusion) and will react immediately onto a collection medium. The medium is then analyzed for NO_2 collected.

The sampler consists of a cylindrical section of rigid plastic tubing of accurately known dimensions (with a length-to-cross section area ratio of 0.1). Reagent (triethanolamine) coated metal screens are enclosed on one end by a plastic cap. The plastic cap that covers the other end is removed to sample the NO_2 in the surrounding air. During analysis, a sulfanilamide-phosphoric acid NEDA solution is added to the dosimeter. The collected NO_2 is desorbed and a red color complex is formed. This solution is then analyzed by spectrophotometry and the NO_2 concentration determined.

To determine concentrations of oxides of nitrogen (NO_x + NO_2), a sampler identical to the passive dosimeter described for nitrogen dioxide was modified by placing a filter impregnated with chromic acid (a strong oxidizing agent) with the collection screens. The NO_x sampler also operates by trapping gas that is transferred by diffusion through a barrier which is an air column defined by a tube of known cross-sectional area and length. Any nitric oxide collected by the dosimeter will then be converted to NO_2 and also absorbed by the triethanolamine. Sampling and analysis methods are otherwise similar to that described for NO_2 dosimeters. Note: If NO_x and NO_2 samplers are exposed simultaneously to the same environment, it is possible to calculate NO concentrations as the difference between NO_x and NO_2 concentrations; this value is divided by 1.3 to give actual NO concentration. The limit of detection for this method is 0.03 ppm.

In addition, area samples for the estimation of nitrogen dioxide and nitric oxide were also collected using an Interscan, Series 4000 NO_2 direct reading monitor for nitrogen dioxide and Interscan, Series 4000 NO direct reading monitor for nitric oxide. These monitors were also connected to Metrosonic, Model 714 data loggers for signal storage and subsequent analysis.

Sulfur Dioxide

Personal breathing zone samples for the estimation of sulfur dioxide (SO_2) were collected using Dräger 5/a-D long term diffusion indicator tubes (Cat.#81 01091). The Dräger tubes contain mercury chloride which reacts with SO_2 to form hydrogen chloride. An acid indicator causes a color change proportional to the SO_2 concentration. These tubes operate on the same principal as the carbon monoxide tubes, except that the indicating layer is of a different chemical reagent. The mean concentration of sulfur dioxide is calculated from the length of discoloration of the reagent material layer, divided by the exposure time. The limit of detection for this method is 0.7 ppm sulfur dioxide for an 8 hour exposure.

Medical

Medical examinations were conducted March 5-11, 1992. These included a questionnaire about work history and health, pulmonary function tests, and serial measurement of peak expiratory flow rates. All employees in the buffing and welding areas were asked to participate.

Questionnaire

A questionnaire addressing respiratory symptoms including asthma, supplemented with questions on job history, cigarette smoking history, acute symptoms which developed during the workshift, demographic information, information on physician-diagnosed respiratory illnesses, and the use of protective devices while working was administered by a trained NIOSH employee.

The following definitions were established for the purpose of analysis:

Chronic cough: a cough on most days for as much as 3 months during the year.

Asthma: any report of asthma, past or present.

Spirometry

Spirometry was performed using a dry rolling-seal spirometer interfaced to a dedicated computer. At least five maximal expiratory maneuvers were recorded for each person. All values were corrected to BTPS (body temperature, ambient pressure, saturated with water vapor). The largest forced vital capacity (FVC), and forced expiratory volume in one second (FEV_1) were the parameters selected for analysis, regardless of the curves on which they occurred. Testing procedures conformed to the American Thoracic Society's recommendations for spirometry.[(2)] Predicted values were calculated using the Knudson reference equations.[(3)] Predicted values for African-Americans were determined by multiplying the value predicted by the Knudson equation by 0.85.[(4)] Test results were compared to the 95th percentile lower limit of normal (LLN) values obtained from Knudson's reference equations to identify participants with abnormal spirometry patterns of obstruction and restriction.[(3)] Five percent of the population will have predicted values that fall below the normal range, or LLN, while 95% will have predicted values above the lower limit.

Using this comparison, obstructive and restrictive lung disease patterns are defined as:

Obstruction: Observed ratio of FEV_1 / FVC% below the LLN.
Restriction: Observed FVC below the LLN; and FEV_1 / FVC% above the LLN.

The criteria for interpretation of the level of severity for obstruction and restriction, as assessed by spirometry, is based on the NIOSH classification scheme (available upon request from the Division of Respiratory Disease Studies). For those persons with values below the LLN, the criteria are:

Classification	*Obstruction (FEV_1/FVC x 100)*	*Restriction (% Predicted FVC)*
Mild	**>60**	**> 65**
Moderate	**≥ 45 to ≤ 60**	**≥ 51 to ≤ 65**
Severe	**< 45**	**< 51**

Cross-shift spirometry was used to document acute airway response. Spirometry was performed pre and post shift on the last day of the participant's work week and again on the first day of the following work week.

Serial Peak Flow Measurements

All currently employed participants were given log sheets and instructed in the use of the Mini-Wright Peak Flow Meter on the first day of the medical survey. Subjects were asked to record flow results from three blows every 2 hours while awake, for 6 consecutive days. The 6 days covered 2 days at the end of the work week, 2 days off, and the first 2 days of the next work week. The presence of symptoms and use of medication during the 2 hours prior to the recording were supposed to be noted on the log sheet.

Peak flow logs from each worker were reviewed for completeness, and were considered interpretable if they met certain criteria. Individual worker records from a 24 hour survey day were considered valid if they contained peak flow results from at least three recording times that spanned at least 8 hours that day. A worker's record was included in the analysis if valid records from a minimum of three of the six survey days were present, including at least one day off work. Logs which failed to meet these minimal criteria were excluded from analysis.

At each peak flow recording time, only the best value (largest of the three recorded values) was used for calculations and subsequent interpretation. Overall variation in peak flow was calculated as the difference between the maximum and minimum best values for the entire survey, divided by the overall mean. Overall variation of > 20% is suggestive of increased airway responsiveness, and if variation > 20% is seen on work days and absent on days off work, a relationship between airflow changes and workplace exposures is suggested.

EVALUATION CRITERIA

As a guide to the evaluation of the hazard posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. Not all workers will be protected from adverse health effects if their exposures are maintained below these levels. It is important to understand that these evaluation criteria are guidelines, not absolute limits between safe and dangerous levels of exposure. A small percentage of workers may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienist' (ACGIH) Threshold Limit Values (TLVs)[(5)], and 3) the U.S. Department of Labor (OSHA) occupational health standards.[(6)] OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used. The NIOSH recommended exposure limits (RELs), by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling (C) values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures. For the substances monitored during this survey, the environmental exposure criteria are summarized in Table 1.

RESULTS

Industrial Hygiene

It is important to note that during this study, personal breathing zone sampling was conducted to determine exposure. Because of that, the results presented in this report will be displayed in a manner as not to identify any particular employee who participated. Each employee who participated in this study was issued a study number for the purposes of coding medical testing results and personal identifier information.

Total Dust

In contrast to fibrogenic dusts which cause scar tissue to be formed in the lungs when inhaled in excessive amounts, so-called "nuisance dust" now termed "Particles Not Otherwise Classified, PNOC" have a long history of little adverse effects on lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. Such dusts have been called (biologically) "inert" dusts, but the latter term is inappropriate to the extent that there is no dust which does not invoke some cellular response in the lung when inhaled in sufficient amount. However, the lung-tissue reaction caused by inhalation of nuisance dust has the following characteristics: the architecture of the air spaces remains intact; scar tissue is not formed to a significant extent; and, the tissue reaction is potentially reversible.

Excessive concentrations of dusts in the workroom air may seriously reduce visibility; may cause unpleasant deposits in the eyes, ears, and nasal passages; or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.[(7)]

The results of the total dust analysis for samples collected during buffing operations are shown in Table 2. A total of twelve personal breathing zone air samples were collected over a three day period on employees performing buffing operations. Exposure concentrations ranged from 0.32 to 77.1 mg/m^3. The mean exposure concentration for the samples was 16.6 mg/m^3 with a standard deviation of 21.8 mg/m^3. Four samples (33%), collected on three employees over the survey period, exceeded the OSHA PEL of 15 mg/m^3, with one sample being 5 times that PEL.

Because dusts generated during buffing operations may contain fractions of elemental metals such as lead, chromium and nickel from the stock being buffed, simply applying the PNOC exposure criteria may not provide adequate protection to the worker. Therefore, a more protective index for determining exposures during buffing operations would be achieved by sampling elemental metals.

Elemental Metals Exposures

The hazard of exposure is dependent upon the metal. Some of the more hazardous metals identified from dust samples collected during welding and buffing operations included lead, nickel, and chromium. Aluminum, although not as hazardous as the other metals identified, was the predominate metal identified on most samples.

The inhalation of very fine aluminum powder in massive concentrations may rarely cause pneumoconiosis in some persons. The metallic dust produced by grinding aluminum products is regarded only as inert dust. The symptoms of long-term overexposure to some fine powders of aluminum may include dyspnea, cough, and weakness. Typically, there may be radiographic evidence of fibrosis and occasional pneumothorax.[(7)]

The dust from chromium metal can be oxidized to a soluble chromium (VI) compound. Samples collected during this survey were assumed to be chromium trioxide fume. There is strong evidence that hexavalent chromium compounds may cause irritation and allergic contact dermatitis, skin ulcers, and nasal irritation varying from rhinitis to perforation of the nasal septum. NIOSH considers chromium (VI) to be an occupational carcinogen.(8)

Inhalation of lead dust and fumes is the major route of lead exposure. A second source of exposure may be from ingestion of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and the blood-forming organs (bone marrow). These effects may be manifested as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency such as slow reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women. (7)

Inorganic nickel compounds are suspected of causing lung and nasal cancers, based on the mortality experience of nickel refinery workers. Occupational exposure to nickel is defined as working with compounds, solutions, or metals containing nickel that can become airborne or can be splashed on the skin or in the eyes. Nickel fumes are respiratory irritants and may cause pneumonitis. Skin contact may cause an allergic skin rash known as "nickel itch". NIOSH considers nickel an occupational carcinogen.(8)

The results of the elemental metal analysis for samples collected during buffing operations are shown in Table 3. A total of 15 personal breathing zone air samples were collected over a three day period on 7 employees engaged in buffing operations. The predominate metal identified on all samples was aluminum. Aluminum was detected on all 14 samples collected. Exposure concentrations for aluminum ranged from 0.9 to 41 mg/m^3. The mean aluminum exposure concentration was 10.3 mg/m^3 with a standard deviation of 12.8 mg/m^3. Three samples (20%) exceeded the OSHA PEL of 15 mg/m^3.

Another metal of significance, identified above the limit of detection for the analytical methods was chromium. Chromium was identified on 8 of 14 samples (57%) analyzed. Personal exposure concentration for chromium ranged from none detected (ND) to 0.004 mg/m^3. The mean exposure concentration was 0.001 mg/m^3 with a standard deviation of 0.001 mg/m^3. All eight samples either equalled or exceeded the NIOSH REL of 0.001 mg/m^3. None of the samples exceeded the OSHA PEL of 0.1 mg/m^3 for chromium.

The results of the elemental metal analysis for samples collected during welding operations are shown in Table 4. A total of 27 personal breathing zone air samples were collected over a three day period on 13 individual employees engaged in welding operations. As seen with buffing, the predominate metal identified on 24 of the 27 samples (88%) was aluminum. Personal exposure concentrations for aluminum ranged from ND - 5.63 mg/m^3. The mean exposure concentration was 0.98 mg/m^3 with a standard deviation of 1.63 mg/m^3. None of the samples collected during welding operations exceeded any exposure criteria for aluminum.

Other metals of significance identified on samples collected during welding operations were chromium, nickel and lead. Chromium was identified on 9 of the 27 (33%) samples collected. Personal exposure concentration for chromium ranged from ND - 0.01 mg/m^3. The mean exposure concentration was 0.004 mg/m^3 with a standard deviation of 0.004 mg/m^3. Of those nine samples where chromium was detected, all equalled and 5 exceeded the NIOSH REL of 0.001 mg/m^3, with two being 10 times higher than the NIOSH REL. None of the samples exceeded the OSHA PEL of 0.1 mg/m^3 for chromium.

Nickel and lead were detected on 2 and 3 samples, respectively. However, the levels detected were below all exposure criteria.

Welding Fume

The results of the total welding fume analysis for samples collected during welding operations are shown in Table 5. A total of 34 personal breathing zone air samples were collected over a three day period on 13 welders. One of those 34 samples collected was voided because of a sampling pump failure. Therefore, only 33 samples were submitted for analysis. Exposure concentrations to total welding fume ranged from 0.1 to 18 mg/m^3. The mean exposure concentration for total welding fume was 2.8 mg/m^3 with a standard deviation of 4.2 mg/m^3. Five samples (15%) exceeded the OSHA PEL of 5 mg/m^3, with two samples being over 3 times the PEL. NIOSH considers welding fume to be a potential occupational carcinogen, primarily due to exposure to metals such cadmium, chromium and nickel. Therefore, NIOSH recommends that exposures be maintained to the "lowest feasible limit" achievable through the use of state-of-the-art engineering controls and good work practices.

Carbon Monoxide

Carbon monoxide (CO) is a colorless, odorless gas, slightly lighter than air. It is produced whenever incomplete combustion of carbon-containing compounds occurs. Typical environmental sources of carbon monoxide exposure, to name a few, are poorly vented heating systems, automobile exhaust, and cigarette smoke. The combination of incomplete combustion and inadequate venting often results in overexposure. The danger of this gas derives from its affinity for the hemoglobin of red blood cells, which is 300 times that of oxygen. The hazard of exposure to CO is compounded by the insidiousness with which high concentrations of carboxyhemoglobin (CO-Hb) can be obtained without marked symptoms.[(9)]

Intermittent exposures are not cumulative in effect and, in general, symptoms occur more acutely with higher concentrations of CO. The NIOSH REL for a TWA exposure to CO is 35 ppm. The OSHA PEL for CO, as revised in 1989 under the Air Contaminants Standard, was identical to the NIOSH REL. However, in 1992, the 11th Circuit Court of Appeals vacated the 1989 Air Contaminants Standard, and Federal OSHA is currently enforcing the previous transitional limits of 50 ppm for a TWA exposure. Some states operating their own OSHA-approved job safety and health compliance programs may continue to enforce the 1989 limits.

Area sampling results for carbon monoxide collected during buffing operations are shown in Table 6. Even though there was no obvious source for carbon monoxide inside the buffing shack, carbon monoxide levels ranged from 23.6 - 69.5 ppm. All but one CO samples collected on March 10, 1992 exceeded the OSHA PEL of 50 ppm for a time weighted average exposure. No nitrogen dioxide, nitric oxide or sulfur dioxide samples were collected in the buffing shack.

Carbon monoxide (CO) was detected on 20 of 23 personal breathing samples collected on welders (Table 7). Personal exposure concentrations for CO ranged from 21.8 to 80.0 ppm. The mean personal exposure concentration was 49.3 ppm with a standard deviation of 22.2 ppm. Ten personal samples (43%) collected on welders exceeded the OSHA exposure criteria of 50 ppm for a time weighted average (TWA) exposure. Eleven personal samples (47%) collected on welders exceeded the NIOSH REL.

In addition to the personal sampling results, real-time area sampling results for carbon monoxide, nitrogen dioxide and nitric oxide are shown in Figures 1-2. These results are shown for March 10 and 11, 1992. Due to a technical problem, data collected on March 9, 1992 was lost. These meters were located in the welding area near the center of all operations. All three gases, nitrogen dioxide, nitric oxide and carbon monoxide, were detected by the direct reading meters. Carbon monoxide was the only gas measured which exceeded the OSHA exposure criteria. Figure 1 shows that when the meters were activated at approximately 7:30 am carbon monoxide readings were already at 45 ppm; slightly below the OSHA criteria of 50 ppm. This reading was verified by short term Dräger carbon monoxide indicator tubes. The carbon monoxide levels shown in Figure 1 averaged 72.2 ppm for an eight hour time weighted average exposure.

Figure 2 shows that on March 11, 1992, carbon monoxide levels were lower than those measured the previous day. The eight hour time weighted average exposure was 30.2 ppm; below the OSHA PEL exposure criteria. Nitrogen dioxide and nitric oxide were again below the OSHA exposure criteria.

Nitrogen Dioxide and Nitric Oxide

Nitric oxide changes into nitrogen dioxide in air. Nitrogen dioxide is more toxic than nitric oxide and may cause severe breathing difficulties which may be delayed in onset. Nitrogen dioxide gas is a respiratory irritant; it causes pulmonary edema and rarely, among survivors, bronchiolitis obliterans. Brief exposure of humans to concentrations of about 250 ppm caused cough, production of mucoid or frothy sputum, and increasing dyspnea. The effects expected in humans from exposure to nitrogen dioxide for 60 minutes are: 25 ppm, respiratory irritation and chest pain; 50 ppm, pulmonary edema with possible subacute or chronic lesions in the lungs; 100 ppm, pulmonary edema and death.[7] The NIOSH REL for nitrogen dioxide is a ceiling exposure of 1 ppm. The OSHA PELs for nitrogen dioxide, as revised in 1989 under the Air Contaminants Standard, was identical to the NIOSH REL. However, in 1992, the 11th Circuit Court of Appeals vacated the 1989 Air Contaminants Standard, and Federal OSHA is currently enforcing the previous transitional limits of 5 ppm for a ceiling exposure. Some states operating their own

OSHA-approved job safety and health compliance programs may continue to enforce the 1989 limits.

A total of 23 personal breathing zone samples for nitrogen dioxide (NO_2) were collected on 13 welders. Nitrogen dioxide was detected on 22 of the 23 samples (Table 7). Personal exposure concentrations for nitrogen dioxide ranged from 0.1 - 1.1 ppm. The mean exposure concentration was 0.31 ppm with a standard deviation of 0.22 ppm. One personal breathing zone sample for nitrogen dioxide exceeded the NIOSH ceiling exposure criteria of 1 ppm. That sample was collected on a welder using 1-1-1 trichloroethane to degrease parts prior to welding. Nitric oxide (NO) was detected on 22 of 23 samples (Table 7). However, nitric oxide levels did not exceed any current exposure criteria.

Sulfur Dioxide

Sulfur dioxide gas is a severe irritant of the eyes, mucous membranes, and skin. Its irritant properties are due to the rapidity with which it forms sulfurous acid on contact with moist membranes. In combination with certain particulate matter and/or oxidants, the effects may be markedly increased. Approximately 90% of all sulfur dioxide inhaled is absorbed in the upper respiratory passages, where most effects occur. High concentrations of sulfur dioxide may produce respiratory paralysis and pulmonary edema. Exposure to concentrations of 10 to 50 ppm can cause irritation to the eyes and nose, runny nose, choking, cough, nosebleeds, and in some instances, reflex bronchoconstriction with increased pulmonary resistance.[(7)] The NIOSH REL for sulfur dioxide is 2 ppm for a TWA exposure. The OSHA PEL for sulfur dioxide, as revised in 1989 under the Air Contaminants Standard, was identical to the NIOSH REL. However, in 1992, the 11th Circuit Court of Appeals vacated the 1989 Air Contaminants Standard, and Federal OSHA is currently enforcing the previous transitional limits of 5 ppm for a TWA exposure. Some states operating their own OSHA-approved job safety and health compliance programs may continue to enforce the 1989 limits.

Sulfur dioxide (SO_2) was detected on 22 of 23 (96%) samples collected on welders. Personal breathing zone exposures for SO_2 ranged from 0.3 - 3.6 ppm. The mean exposure concentration was 1.5 ppm with a standard deviation of 0.79 ppm SO_2. Five personal samples (22%) collected for sulfur dioxide exposure exceeded the NIOSH REL of 2 ppm for an 8 hour time weighted average exposure. Every sample which exceeded the exposure criteria was collected on March 10, 1992.

Medical

The participants were divided into two groups: current buffers and current welders. All current buffers and welders participated in the survey. The seventeen buffers ranged in age from 21 to 38 and had a median tenure of 11 months. The twenty-one welders ranged in age from 23 to 54 and their median tenure was 57 months.

Questionnaire

The prevalences of reported chest symptoms were similar between the buffers and welders (Table 8). For symptoms that increased in frequency after starting work at Dee Zee, the complaints were similar for eye and nose irritation but higher for ear pain, nosebleeds, and skin rashes in the buffer group (Table 9). Four welders and two buffers reported that they have asthma which started in childhood. All six are current or former cigarette smokers. A safety concern for both welders and buffers is the number of reported foreign objects (sparks, slag, or metal chips) in the eyes and ears. Fourteen participants reported getting objects in their eyes, with 3 reporting this has occurred more than 6 times. Three participants reported getting foreign objects in their ears.

Spirometry

When the pulmonary function results were compared according to job category, there was very little difference in mean pulmonary function values between the welders and buffers (Table 10). However, when categorized by smoking, former and current smokers exhibited lower mean FEV_1 and mean FEV_1/FVC ratio values (Table 11). Of the 38 participants, eight (6 welders and 2 buffers) had mild obstructive lung disease patterns and were either current smokers, or in one case, a former smoker. Two of these individuals also reported having asthma.

The change in FEV_1 percent was calculated for each current employee across the first day of their work week, the last day of their work week, and over the weekend. Fifteen participants (39%) exhibited at least one of the following: 1) a 5% drop in FEV_1 across the shift on Friday, 2) a 5% drop in FEV_1 across the shift on Monday, or 3) a 5% increase in FEV_1 over the weekend. Seven (2 welders and 5 buffers) showed a greater than 5% decrease on Friday, 11 (5 welders and 6 buffers) had a 5% or greater drop on Monday, and 6 (2 welders and 4 buffers) had at least a 5% improvement from Friday to Monday. Of the fifteen, 3 (all buffers) showed drops in their FEV_1 on Friday and Monday and had a 5% or better improvement over the weekend. These changes are suggestive of a relationship to work.

Serial Peak Flow Monitoring

All 38 employees participated in the collection of peak flow data. Thirty-seven participants provided peak flow data suitable for interpretation. Of these, 12 showed a 20% or greater change on one or more days, and of these 12, four (1 welder and 3 buffers) had a temporal pattern suggesting a relationship to their work.

Four of the six individuals who reported having asthma showed a greater than or equal to 20% change in peak flow, and two (1 welder and 1 buffer) appeared to show a relationship to work.

Of the eight who showed mild obstructive patterns in their pulmonary function, four showed a 20% or greater change in their peak flow, although none of these appeared to have a work relationship.

CONCLUSIONS

During this survey period, results of the environmental sampling conducted at Dee Zee indicate that a health hazard existed for buffing and welding employees. Personal breathing zone concentrations above the OSHA PEL and/or the NIOSH REL were measured for dusts, welding fume, aluminum, chromium, carbon monoxide, nitrogen dioxide, and sulfur dioxide. Of particular concern were the over-exposures of welding and buffing employees to total welding fume and chromium, since both are considered by NIOSH as occupational carcinogens.

All buffers were observed wearing approved respiratory protection during buffing operations. The workers' actual exposures to the levels of dust and aluminum may have been somewhat less due to the use of respiratory protection. However, respirator effectiveness appeared compromised by the poor face fit, and obvious face seal leaks which resulted in substantial amounts of dust in and around the workers' nasal passages. No welders were observed using respiratory protection.

In evaluating all sampling results, it appears that the most widespread health hazard to *all* employees at Dee Zee is from exposure to carbon monoxide. Exposure to carbon monoxide was not isolated to welding or buffing employees alone, but was found throughout the facility, endangering all employees. Sources of the carbon monoxide are forklifts, welding operations and the gas fired powder bake oven. On the morning of March 10, 1992, the NIOSH investigators observed a smokey haze in both the production and manufacturing area of the facility. Indicator tube readings for carbon monoxide showed substantial levels (> 100 ppm) of carbon monoxide adjacent to the ovens in the production area. The plant manager was immediately notified of our concerns and began to investigate the problem. It appears that the oven exhaust fans were turned off because of difficulties of maintaining oven temperatures due to the extremely cold outside temperatures. In addition, a ceiling exhaust fan was not working because of a defective motor. Incidentally, all samples for carbon monoxide, nitrogen dioxide and sulfur dioxide which exceeded current exposure criteria were collected on March 10, 1992.

The high number of participants with obstructive lung disease patterns among those who did spirometry, 21% as compared to 8% for a group of non-dust exposed blue collar workers, [11] suggests that a problem exists among these workers. This seems to be reinforced by the finding that 15 of the 38 showed a 5% or greater change in FEV_1 across a work day or the weekend. Twelve of the 38 also showed a 20% or greater change in peak flow with four (3 buffers and 1 welder) showing a temporal pattern suggestive of a work-related cause.

RECOMMENDATIONS

1. Since carbon monoxide is a colorless, odorless and tasteless gas having poor warning properties, an active carbon monoxide monitoring program should be instituted throughout the facility. This could be accomplished by installing fixed point monitors throughout the facility to continually measure carbon monoxide levels. These monitors should have alarms to warn employees when corrective actions are necessary.

2. The exhaust ventilation system for the ovens should be continually inspected to assure proper operation. In addition, exhaust fan grills should be free of obstructions to ensure proper air flow.

3. The exhaust ventilation system for the welding areas needs to be redesigned for more efficient use. The exhaust hoods are large, heavy, and cumbersome making them difficult to be easily moved close to the welding operation. In order for the system to work properly and effectively remove the welding fumes, the hoods have to be placed close to the welding site. The further the hood is away from the welding site, the less efficient it is. An engineering firm familiar with ACGIH Industrial Ventilation recommendations should be retained to redesign the exhaust hoods in the welding area. In addition, any welding which is now accomplished under a canopy hood should be discontinued until an exhaust hood can be designed to be located in close proximity to the welding site.

4. The use of 1-1-1 trichloroethane to clean parts prior to welding should be discontinued. This procedure could generate phosgene gas which is an extreme health hazard. Other substitutes for the trichloroethane should be investigated, such as hot soapy water, or other non hydrocarbon based solutions.

5. The ventilation system in the buffing shack should be removed and a new system designed in order to reduce employee exposures to dusts from buffing and grinding. The new system should conform to ACGIH Industrial Ventilation guidelines for buffing and grinding operations.[12] An engineering firm familiar with these guidelines should be retained to redesign a new system. This new system should have the exhaust hoods located as close to the work as possible to capture the dust generated from the buffing operations.

6. During this survey, it was obvious that Dee Zee relies on the use of personal respiratory protection for buffing room employees. The primary means of respiratory protection is

through the use of NIOSH/MSHA approved (TC 21 series) respirators. Based on the discussions with the workers, problems in the respiratory protection program were noted. First, the workers are not adequately informed on the proper use of the respirators provided, nor properly informed of the health hazards associated with their jobs. Secondly, workers complained that there was no established program to evaluate the effectiveness of the issued respirators, no fit testing program, and no instruction in the proper use of respirators. Finally, many respirators inspected were in poor condition. Many had poorly fitting head straps, missing parts and were not properly cleaned or stored. Until such time as effective engineering controls are installed, a mandatory personal protective equipment policy should be established to require the use of certified respirators in the buffing shack. A respiratory protection program should be in place which meets the requirements of 29 CFR 1910.134 of the OSHA standard.

7. In accordance with OSHA regulation 29 CFR 1910.1200, each employee exposed to hazardous substances needs to be apprised, at the beginning of his employment or assignment, of the hazards, relevant symptoms, appropriate emergency procedures, and proper conditions and precautions for safe use or exposure. Such information should be kept on file and should be accessible to the worker at each place of employment where hazardous materials are involved in unit processes and operations. Workers should also be advised of the increased risk of impaired health due to the combination of exposures, including smoking.

8. Because employees with overt cardiovascular disease may not be protected by an occupational exposure to 35 ppm of CO, a medical program should be instituted consisting of preplacement and periodic examinations with special attention to the cardiovascular system and to medical conditions which could be exacerbated by exposure to CO. Such a program could also provide the opportunity for conducting smoking cessation programs for all employees.

9. Medical surveillance with particular emphasis on the respiratory system should be made available to all workers subject to buffing and welding operations. Initial examinations should be offered prior to beginning employment and annually or as otherwise indicated by the responsible physician. The examination should include: 1) Comprehensive or interim medical and work histories, 2) Pulmonary function tests, 3) A judgement of the worker's physical ability to use negative or positive pressure respirators as defined in 29 CFR 1910.134. For those workers subject to exposure to sulfur dioxide, the examination should also include the eyes. Particular attention should be focused on complaints of mucous membrane irritation and cough. All medical records with pertinent supporting documents should be maintained at least 20 years after the individual's employment is terminated.

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AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:	Joseph E. Burkhart, MS, CIH Elizabeth B. Knutti, BSN, RN
Field, Medical and Statistical Assistance by:	Chris Piacitelli Steve Berardinelli, Jr. Teresa Buchta Corrado Ugolini, MD Kathleen B. Kinsley
Originating Office:	Respiratory Disease Hazard Evaluation and Technical Assistance Program Division of Respiratory Disease Studies 1095 Willowdale Road Morgantown, West Virginia 26505 (304) 291-4203

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1. Requestor (Confidential)
2. Dee Zee Manufacturing, Inc.
3. Iowa Division of Labor Services, Occupational Safety and Health Bureau
4. Occupational Safety and Health Administration, Des Moines, Iowa

For the purpose of informing affected employees, copies of this report should be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1.
Environmental Exposure Criteria

Substance	NIOSH (REL)	OSHA (PEL)
Dust (Particles Not Otherwise Classified)	None	15 mg/m^3
Welding Fume	Ca *	5 mg/m^3
Metals		
Aluminum	10 mg/m^3	15 mg/m^3
Chromium (as CrO_3)	.001 mg/m^3 *	0.1 mg/m^3 (C)
Nickel	.015 mg/m^3 *	1.0 mg/m^3
Lead	0.1 mg/m^3	0.05 mg/m^3
Gases		
Carbon Monoxide	35 ppm	50 ppm
Nitrogen Dioxide	1 ppm (STEL)	5 ppm (C)
Nitric Oxide	25 ppm	25 ppm
Sulfur Dioxide	2 ppm	5 ppm

All exposure criteria expressed as Time Weighted Average (TWA) concentrations unless otherwise indicated.

* = Because this substance is a potential occupational carcinogen, the NIOSH policy for exposure is lowest feasible limit.

(STEL) = Short Term Exposure Limit of 15 minutes.

(C) = Ceiling concentration, not to be exceeded during any part of the working exposure.

Table 2.
Personal Sampling Results of Total Dust Exposure
for Buffing Operations
March 9-11, 1992

Participant ID*	Sample No.	Sample Vol. (liters)	Concentration (mg/m^3)	Collection Date
91142003	7755	737	39.1	10-Mar
91142003	7741	753	15.9	11-Mar
91142005	7805	788	0.32	09-Mar
91142005	7748	728	11.0	10-Mar
91142005	7729	276	13.1	11-Mar
91142007	7744	738	5.1	10-Mar
91142007	7728	750	4.6	11-Mar
91142035	7731	458	77.1	10-Mar
91142035	7742	803	3.7	11-Mar
91142036	7793	839	0.4	09-Mar
91142036	7753	758	20.0	10-Mar
91142036	7723	746	9.0	11-Mar

Table 3.
Personal Sampling Results of Elemental Metals Exposure (mg/m^3)
for Buffing Operations
March 9-11, 1992

Participant ID	Sample Number	Collection Date	Sample Vol. (l)	Aluminum (mg/m^3)	Chromium (mg/m^3)	Nickel (mg/m^3)	Lead (mg/m^3)
142003	18407	09-Mar	837	12.0	0.001	ND	0.001
142003	18397	10-Mar	737	7.6	0.001	ND	ND
142003	20389	11-Mar	753	6.1	ND	ND	ND
142005	19471	10-Mar	728	4.4	0.001	ND	ND
142005	18406	11-Mar	276	0.9	0.004	ND	ND
142007	20596	09-Mar	void				
142007	20612	10-Mar	738	1.9	0.001	ND	ND
142007	18410	11-Mar	750	1.0	ND	ND	ND
142010	20346	09-Mar	786	4.6	ND	ND	ND
142010	20597	10-Mar	732	41.0	ND	ND	ND
142015	19461	10-Mar	713	5.2	0.001	ND	ND
142035	20379	10-Mar	728	26.1	ND	ND	ND
142035	20644	11-Mar	803	1.3	0.001	ND	ND
142036	20651	10-Mar	757	30.4	ND	ND	ND
142036	20632	11-Mar	745	1.8	0.001	ND	ND

Table 4.
Personal Sampling Results of Elemental Metals Exposure (mg/m^3) for Welding Operations
March 9-11, 1992

Participant ID	Sample Number	Collection Date	Sample Vol. (l)	Aluminum (mg/m^3)	Chromium (mg/m^3)	Nickel (mg/m^3)	Lead (mg/m^3)
142012	20610	10-Mar	761	ND	0.01	0.01	0.01
142012	20613	11-Mar	751	0.37	ND	ND	ND
142013	20370	10-Mar	750	0.04	ND	ND	ND
142013	20630	11-Mar	753	0.04	ND	ND	ND
142014	19483	09-Mar	837	5.50	ND	ND	ND
142014	20366	10-Mar	828	ND	0.01	0.01	0.01
142014	19482	11-Mar	826	0.12	ND	ND	ND
142015	20615	10-Mar	783	0.03	ND	ND	ND
142016	20380	10-Mar	752	0.11	ND	ND	ND
142016	20640	11-Mar	737	0.11	ND	ND	ND
142017	20353	10-Mar	762	0.10	ND	ND	ND
142017	20388	11-Mar	760	ND	ND	ND	ND
142018	20621	10-Mar	738	1.34	ND	ND	ND
142018	19490	10-Mar	792	1.25	ND	ND	ND
142019	20609	09-Mar	817	5.63	ND	ND	ND
142019	20598	10-Mar	729	1.36	ND	ND	ND
142019	20600	11-Mar	735	0.38	ND	ND	ND

Table 4. (continued)
Personal Sampling Results of Elemental Metals Exposure (mg/m^3)
for Welding Operations
March 9-11, 1992

Participant ID	Sample Number	Collection Date	Sample Vol. (l)	Aluminum (mg/m^3)	Chromium (mg/m^3)	Nickel (mg/m^3)	Lead (mg/m^3)
142020	18403	10-Mar	723.00	1.1	ND	ND	ND
142021	20625	10-Mar	801	0.4	0.001	ND	ND
142022	18411	09-Mar	745	0.1	0.001	ND	ND
142022	18409	10-Mar	746	0.1	0.001	ND	ND
142023	19475	09-Mar	745	1.5	0.005	ND	ND
142023	18398	10-Mar	656	0.1	ND	ND	ND
142023	20649	11-Mar	832	3.7	0.004	ND	ND
142040	20358	09-Mar	747	0.04	0.002	ND	0.001
142040	20390	10-Mar	762	0.1	0.001	ND	ND
142040	20381	11-Mar	765	0.01	ND	ND	ND

Table 5.
Personal Sampling Results of Total Welding Fume Exposure for Welding Operations
March 9-11, 1992

Participant ID	Sample No.	Sample Vol. (liters)	Concentration (mg/m^3)	Collection Date
91141012	7760	761	0.8	10-Mar
91142012	7719	752	4.1	11-Mar
91142013	7783	728	0.5	09-Mar
91142013	7747	759	1.1	10-Mar
91142013	7726	753	0.5	11-Mar
91142014	7800	839	0.7	09-Mar
91142014	7740	828	1.5	10-Mar
91142014	7738	827	3.1	11-Mar
91142015	7784	857	6.0	09-Mar
91142015	7749	783	2.6	10-Mar
91142016	7790	746	0.8	09-Mar
91142016	7745	752	0.7	10-Mar
91142016	7712	737	0.1	11-Mar
91142017	7818	746	0.6	09-Mar
91142017	7746	762	1.8	10-Mar
91142017	7743	761	1.0	11-Mar
91142018	7806	834	0.6	09-Mar
91142018	7756	792	17.2	10-Mar
91142018	7733	819	0.5	11-Mar
91142019	7817	839	0.7	09-Mar
91142019	7754	729	0.8	10-Mar
91142019	7727	735	0.6	11-Mar

Table 5. (Continued)
Personal Sampling Results of Total Welding Fume Exposure
for Welding Operations
March 9-11, 1992

Participant ID	Sample No.	Sample Vol. (liters)	Concentration (mg/m^3)	Collection Date
91142020	7765	720	4.5	09-Mar
91142020	7751	723	5.7	10-Mar
91142021	7788	698	1.1	09-Mar
91142021	7757	801	1.7	10-Mar
91142022	7771	744	0.6	09-Mar
91142022	7752	746	0.4	10-Mar
91142023	7777	746	18.0	09-Mar
91142023	7758	656	0.6	10-Mar
91142023	7736	833	7.6	11-Mar
91142040	7789	747	2.9	09-Mar
91142040	7750	762	2.4	10-Mar
91142040	7735	765	VOID	11-Mar

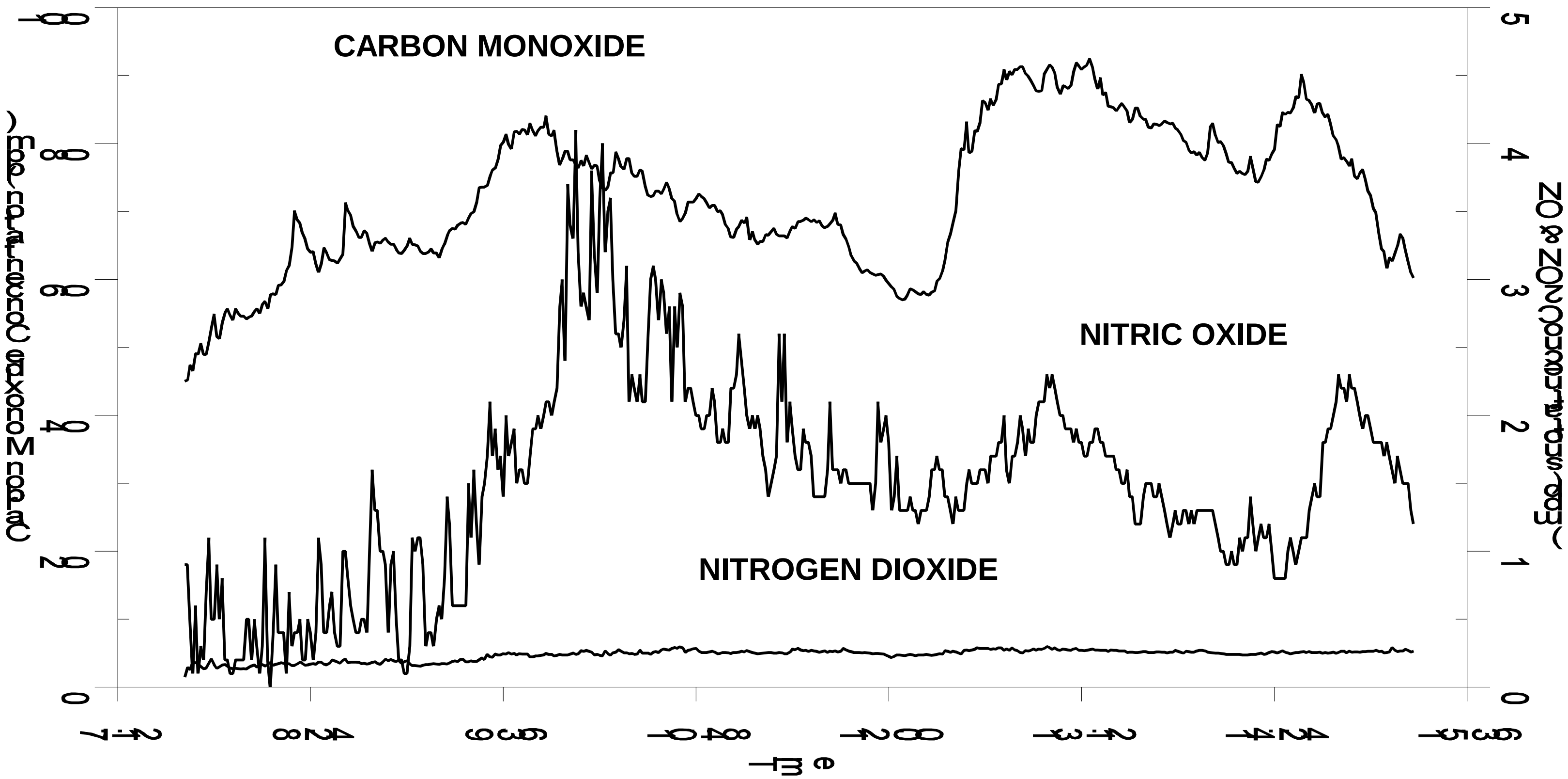
Table 6.
Area Sampling Results of TWA Carbon Monoxide Exposures for Buffing Operations

Area Sampling Location	Carbon Monoxide (ppm)	Collection Date
Between 150 & 300 grit Buffers	23.6	09-Mar
Grinder	27.2	09-Mar
Horizontal Buffer	30.5	09-Mar
Between 150 & 300 grit Buffers	60.5	10-Mar
Grinder	64.2	10-Mar
Polisher	65.4	10-Mar
Horizontal Buffer	69.5	10-Mar

Table 7.
Personal Sampling Results of TWA Gas Exposures for Welding Occupations

Participant ID	Nitrogen Dioxide (ppm)	Nitric Oxide (ppm)	Carbon Monoxide (ppm)	Sulfur Dioxide (ppm)	Collection Date
91142012	0.2	1.2	71.3	2.4	10-Mar
91142013	0.2	0.7	30.9	0.9	09-Mar
91142013	0.2	1.2	70.1	1.8	10-Mar
91142014	0.2	1.9	27.8	1.1	09-Mar
91142014	0.4	1.1	65.1	1.1	10-Mar
91142015	0.2	1.2	26.2	1.1	09-Mar
91142015	0.2	1.0	65.5	1.5	10-Mar
91142016	void	void	24.1	0.9	09-Mar
91142016	0.2	1.2	71.7	1.2	10-Mar
91142017	0.2	0.8	24.2	0.9	09-Mar
91142017	0.4	2.0	70.8	0.9	10-Mar
19142018	0.3	1.4	21.8	0.8	09-Mar
19142018	0.3	1.1	64.5	2.2	10-Mar
19142019	0.3	1.7	27.5	1.1	09-Mar
19142019	0.3	0.7	49.3	2.5	10-Mar
19142020	0.3	0.9	74.7	2.5	10-Mar
91142021	0.2	1.1	67.4	1.7	10-Mar
91142022	0.8	3.8	void	void	09-Mar
91142022	1.1	4.3	void	3.6	10-Mar
91142023	0.2	0.8	24.2	0.3	09-Mar
91142023	0.1	1.0	80.0	0.7	10-Mar
91142040	0.3	0.5	30.1	0.9	09-Mar
91142040	0.2	0.4	void	1.8	10-Mar

Figure 1.
Real-Time Sampling Results for Carbon Monoxide
Nitrogen Dioxide and Nitric Oxide Gases
March 10, 1992



Dee Zee Manufacturing Inc.
Des Moines, IA
HETA 91-142

Figure 2.
Real-Time Sampling Results for Carbon Monoxide
Nitrogen Dioxide and Nitric Oxide Gases
March 11, 1992

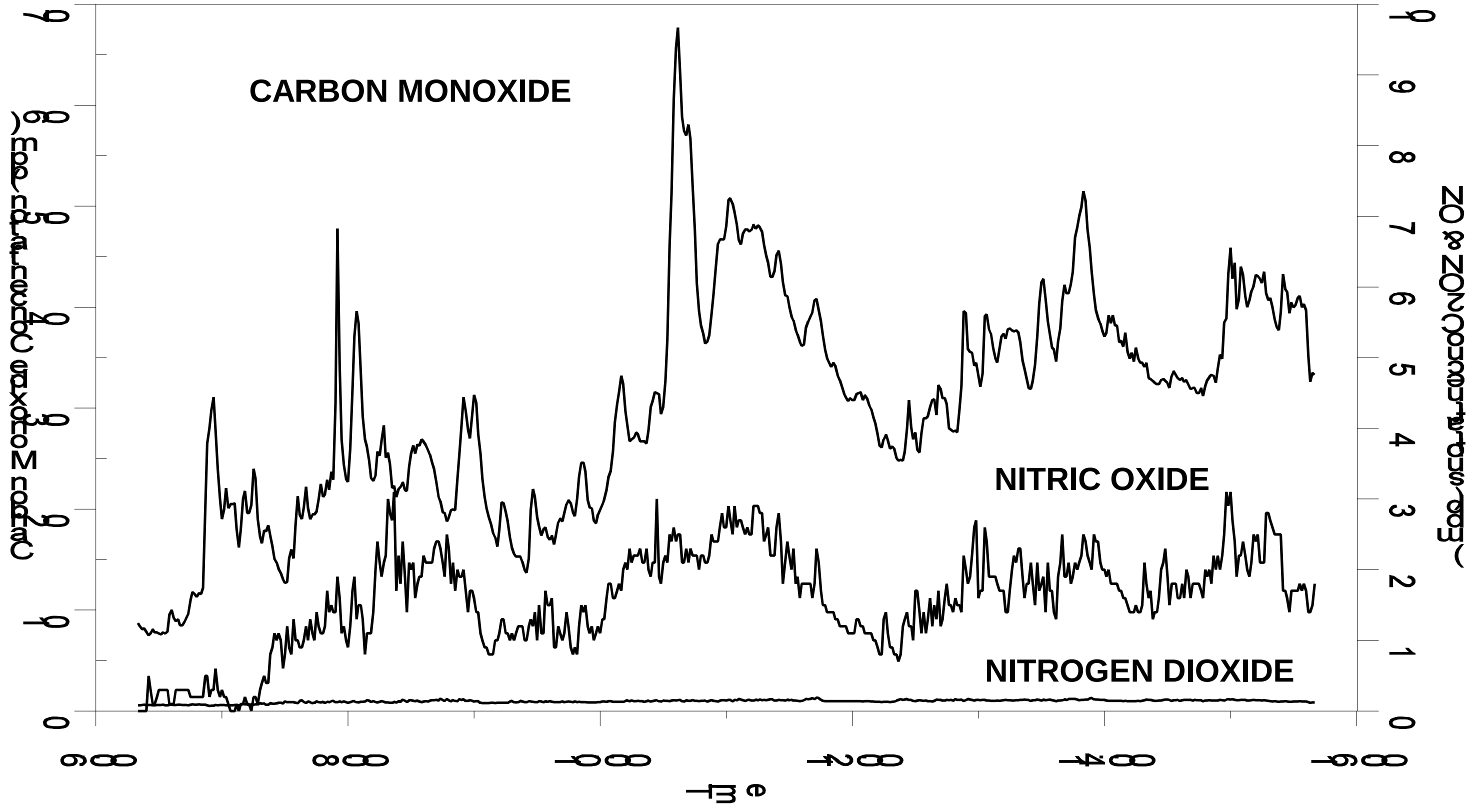


Table 8.
Reported Symptom Prevalence for Current Buffers and Welders

	BUFFER N=17		WELDER N=21		ALL N=38	
	Yes	%	Yes	%	Yes	%
Q1 - Chest ever wheeze or whistle?	10	59	10	48	20	53
Q2 - Ever short of breath?	7	41	7	33	14	37
Q3 - Chest ever feel tight?	6	35	7	33	13	34
Q4 - Chronic cough?	7	41	5	24	12	32

Table 9.
Reported Prevalence of Symptoms that Increased after Starting Work at Dee Zee for Current Buffers and Welders

	BUFFER N=17		WELDER N=21		ALL N=38	
	Yes	%	Yes	%	Yes	%
Q5 - Itchy, runny, stuffy nose	8	47	9	43	17	45
Q6 - Sneezing	8	47	5	24	13	34
Q7 - Itchy, watering, tearing eyes	8	47	8	38	16	42
Q8 - Ear pain or discharge	5	29	2	10	7	18
Q9 - Nosebleeds	4	25*	1	5	5	14*
Q10 - Skin rashes, dermatitis, etc	9	53	3	14	12	32

* = One participant did not answer the question concerning nosebleeds.

Table 10.
Pulmonary Function Test Results for Current Buffers and Welders

	Buffer N=17		Welder N=21	
	Mean	SD	Mean	SD
FVC (l)	5.37	0.70	5.46	0.92
% Predicted FVC	103.0	11.8	100.0	13.8
FEV_1 (l)	4.21	0.61	4.23	0.93
% Predicted FEV_1	95.9	14.5	92.6	16.2
FEV_1 /FVC (%)	78.6	6.9	77.2	7.8

Table 11.
Pulmonary Function Test Results
Presented by Cigarette Smoking Habit

	Never		Former		Current	
	N=9		N=3		N=26	
	Mean	SD	Mean	SD	Mean	SD
FVC (l)	5.41	0.74	5.11	0.36	5.46	0.89
% Predicted FVC	102.7	9.2	100.7	11.4	100.9	14.4
FEV_1 (l)	4.48	0.75	3.75	0.57	4.19	0.82
% Predicted FEV_1	99.7	12.4	88.7	4.0	92.7	16.8
FEV_1 /FVC (%)	82.6	4.0	73.5	11.4	76.7	7.3